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A progress report on the estimation of geoacoustic parameters from measured time series taken during the East China Sea component of ASIAEX

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Prepared for ASIAEX Analysis International Symposium October 14-18 Chengdu, China

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **01 DEC 2002**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **A Progress Report on the Estimation of Geoacoustic Parameters from Measured Time Series Taken During the East China Sea Component of ASIAEX**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Applied Research Lab., The University of Texas at Austin, BBN Technologies, and ASIAEX Collaborators**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**		
13. SUPPLEMENTARY NOTES **Also See: M001452, The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**20**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

OUTLINE

I. Modeling of forward transmission data

II. Comparisons to analyses of previous experiments

III. Summary and future work

Issues and Objectives

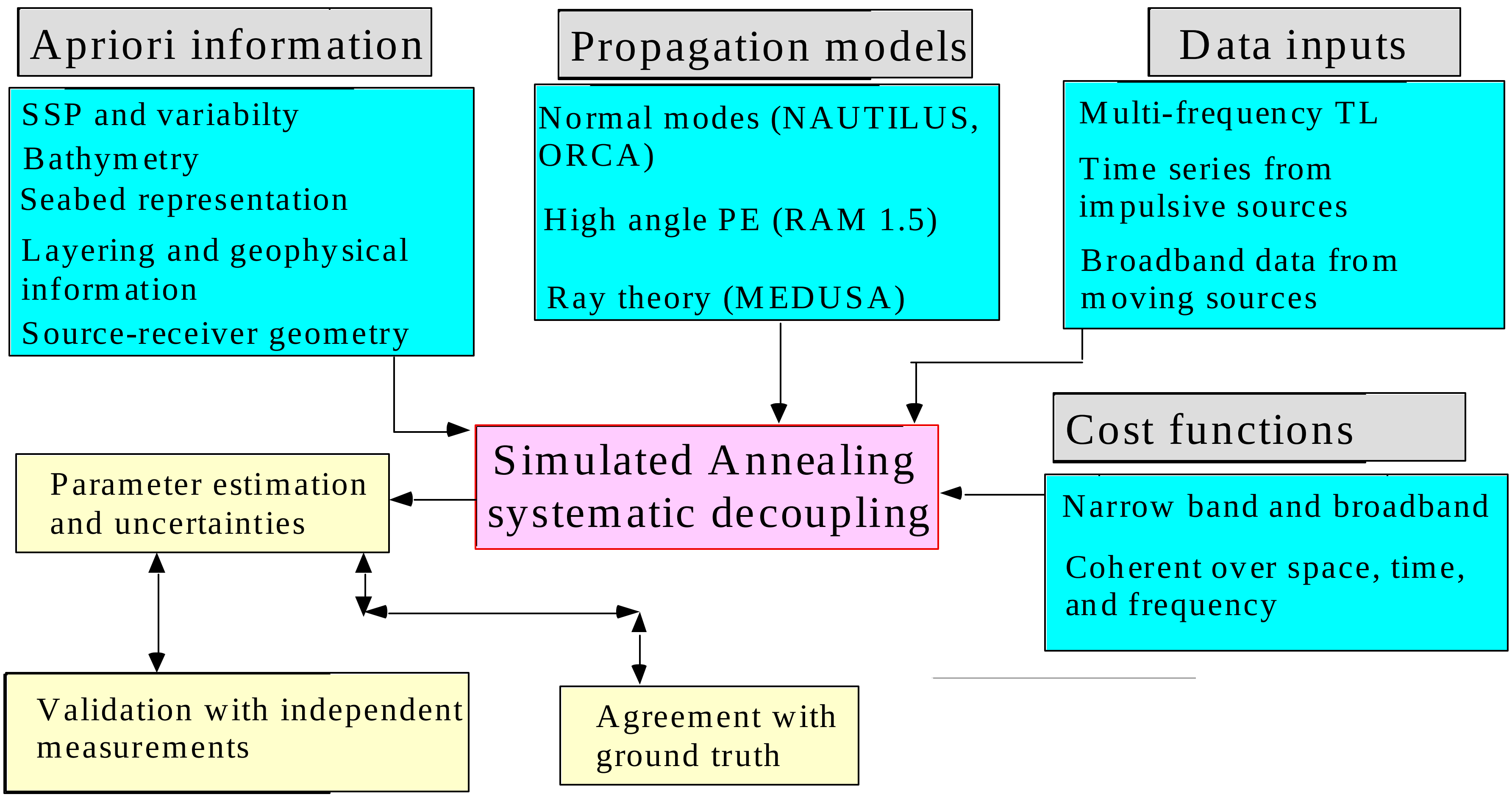
Extract information on physics of low-frequency scattering from seabed

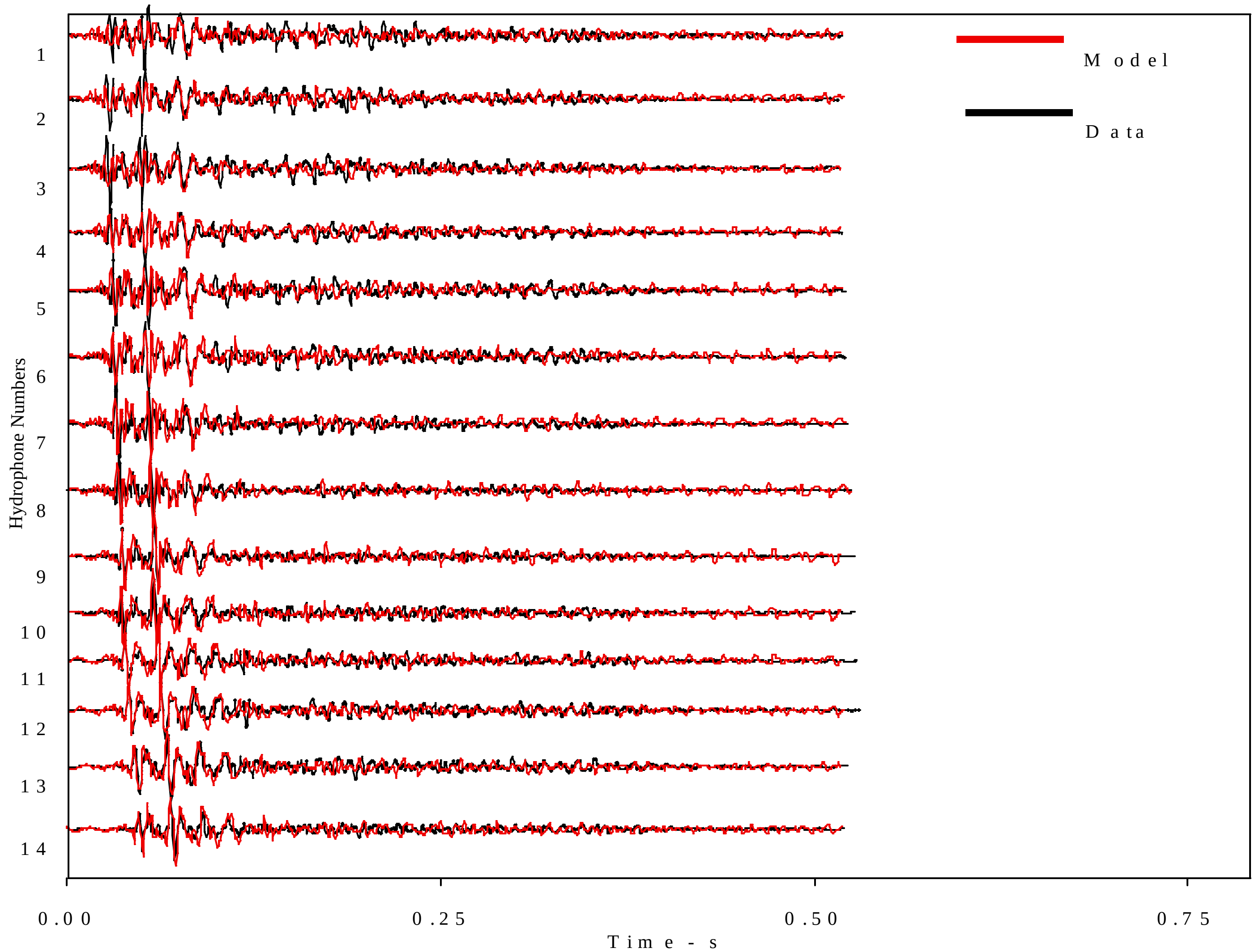
Use acoustic forward transmission data to establish average geoacoustic structure

Employ this information in the scattering equations to invert for the scattering potential of the seabed using reverberation data.

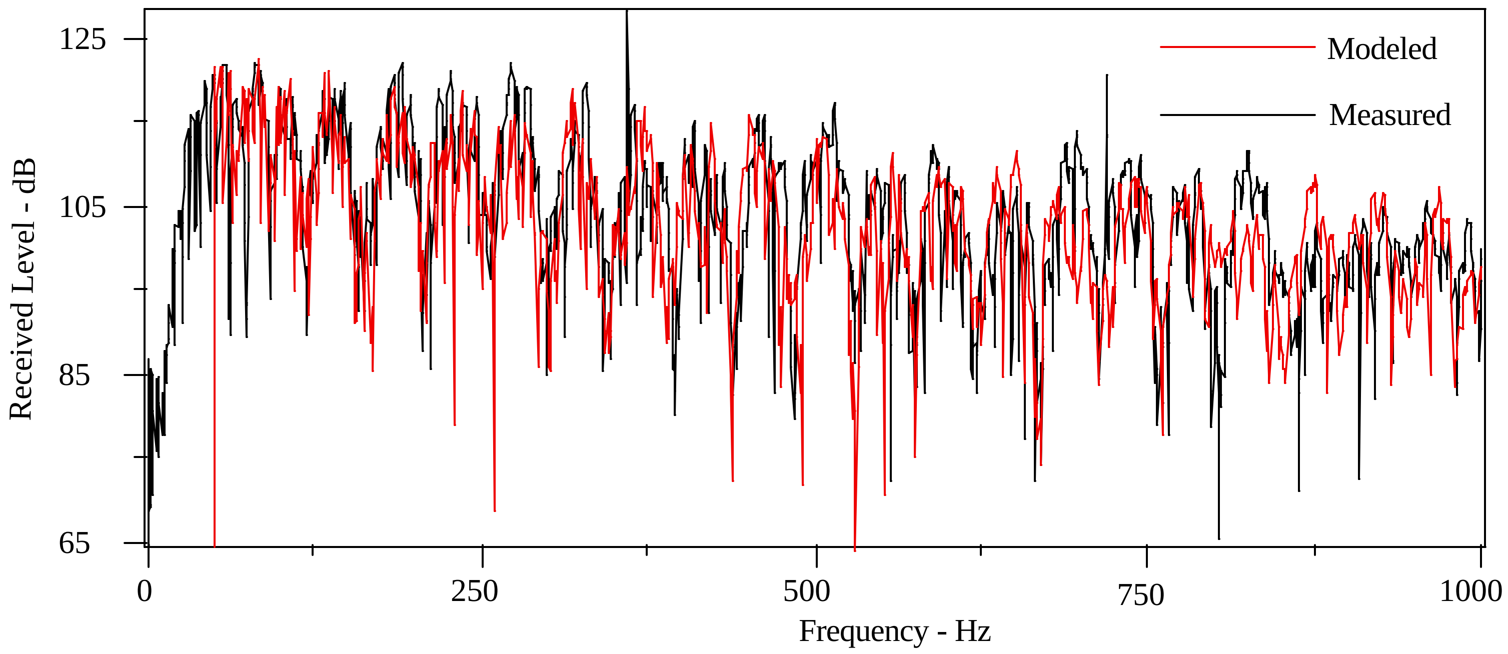
What features in the forward data allow for extraction of sound speed and attenuation structure?

ARL Analysis and Inversion Methodology





Comparison of measured and modeled time series data on the
APL/URI VLA. Range = 16.94 km, source depth = 55 m



Comparison of measured and modeled magnitude of spectra for a single phone on VLA in East China Sea measurements. Source-receiver range = 16.94 km. Source depth 55 m. Source spectra from Chapman-Wakely model convolved with modeled frequency response in 50-350 Hz band. Modeled frequency response made with ORCA normal mode model.

Depth - m	Compressional Speed - m/s	Density - g/cc	Attenuation db/m-kHz	Frequency Exponent	
0.0	1640.0	1.76	0.45	1.8	Sand
7.6	1664.9	1.76	0.45	1.8	
7.6	1839.8	1.9	0.27	1.0	Sand-Gravel
95.5	1918.1	1.9	0.27	1.0	
95.5	3000.0	2.5	0.02	1.0	Basement

Current Estimated Geoacoustic Profile
in ECS basin from data analysis

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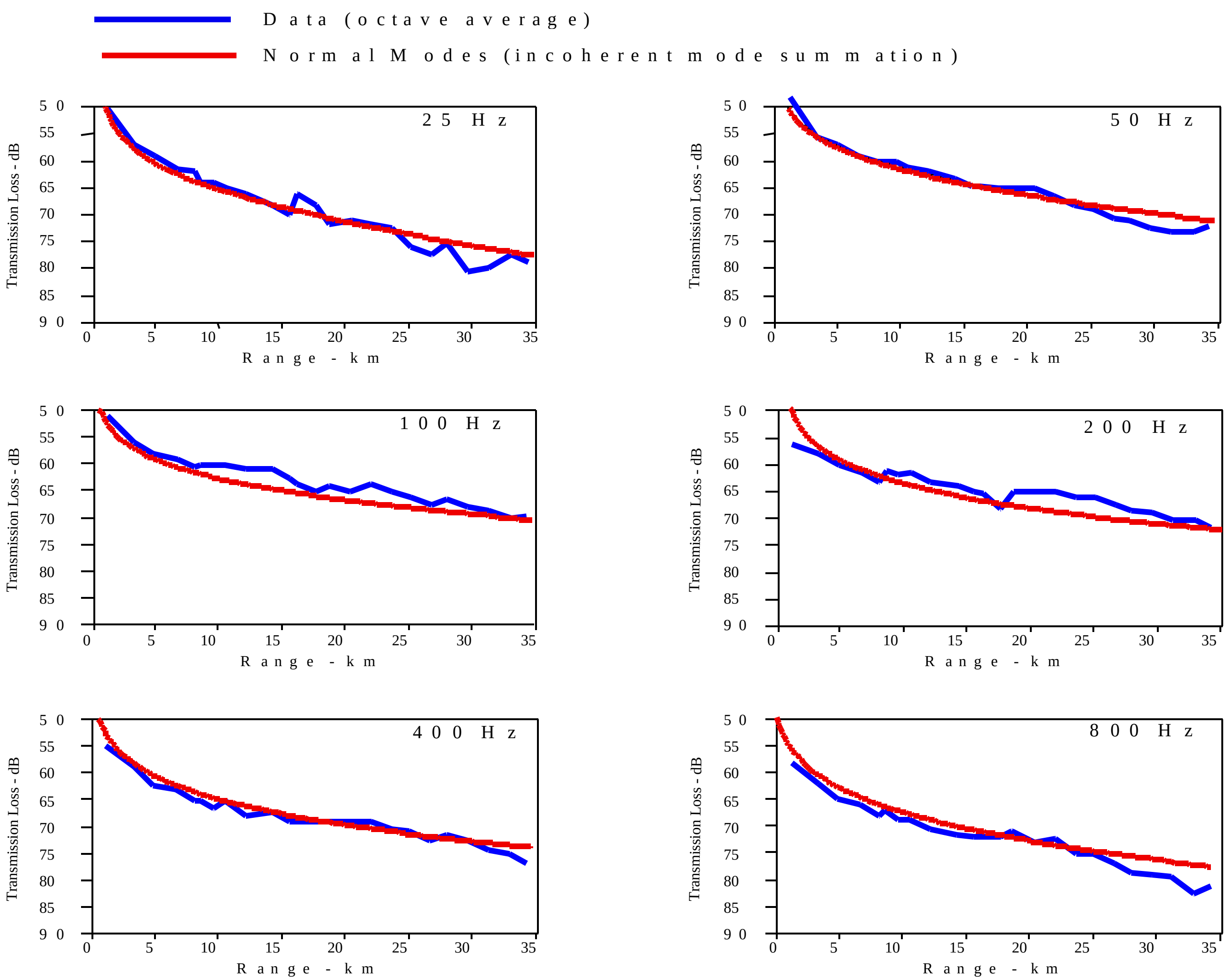

Comparison of modeled TL using the ECS geoacoustic profile to m
TL taken at 29 05 N 126 43 E.

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Observations

Estimated sound speed structure of upper 10 m of sediment describes relative arival times of main multipath arrivals and general time spread characteristics as a function of range. Arrivals demonstrate critical angle effect at the water sediment interface.

A top sediment sound speed of 1640 m/s with a high sound speed depth gradient appears to be the key structure of the geoacoustic profile. Analysis, however, may have slightly overestimated sound speed because of incorrect water depth.

Very difficult to establish precise sediment thickness from time series data.

Comparisons of geoacoustic profiles in ECS region

East China Sea basin Yellow Sea basin Southern Strait of Korea*

Depth - m			Compressional Speed - m/s			Density - g/cc			Attenuation db/m-kHz			Frequency Exponen		
0.0	0.0	0.0	1640.0	1644.7	1629.0	1.76	1.72	1.88	0.45	0.89	0.28	1.8	2.0	1.8
7.62	5.96	10.0	1664.9	1650.4	1644.0	1.76	1.72	1.88	0.45	0.94	0.30	1.8	2.0	1.8
7.62	5.96	10.0	1839.8	1725.3	1760.0	1.9	1.8	1.95	0.27	0.47	0.15	1.0	1.3	1.8
95.48	131.9	132.0	1918.1	1848.9	1761.0	1.9	1.8	1.95	0.27	1.0	0.15	1.0	1.3	1.8
95.48	131.1	132.0	3000.0	3000.0	2200.0	2.5	2.5	2.2	0.02	0.02	0.02	1.0	1.0	1.0

Geoacoustic Models for ECS and YS basins and SOK Obtained From Analysis and Inversion of TL and Time Series Data.

* Rozenfeld et al IEEE JOE

** Knobles et al

Summary

An approximate geoacoustic description has been established for ECS
Consistent with previous geophysical measurements.

Key characteristics of both forward time series and
transmission loss measurements are reproduced by range-independent

Geoacoustic model used in analysis of scattering data.

Uniqness of attenuation and layering structure in seabed difficult to es

Elastic description may be required for consistent picture
of seabed acoustics.

Modeling of ASIAEX Reverberation

Research in progress

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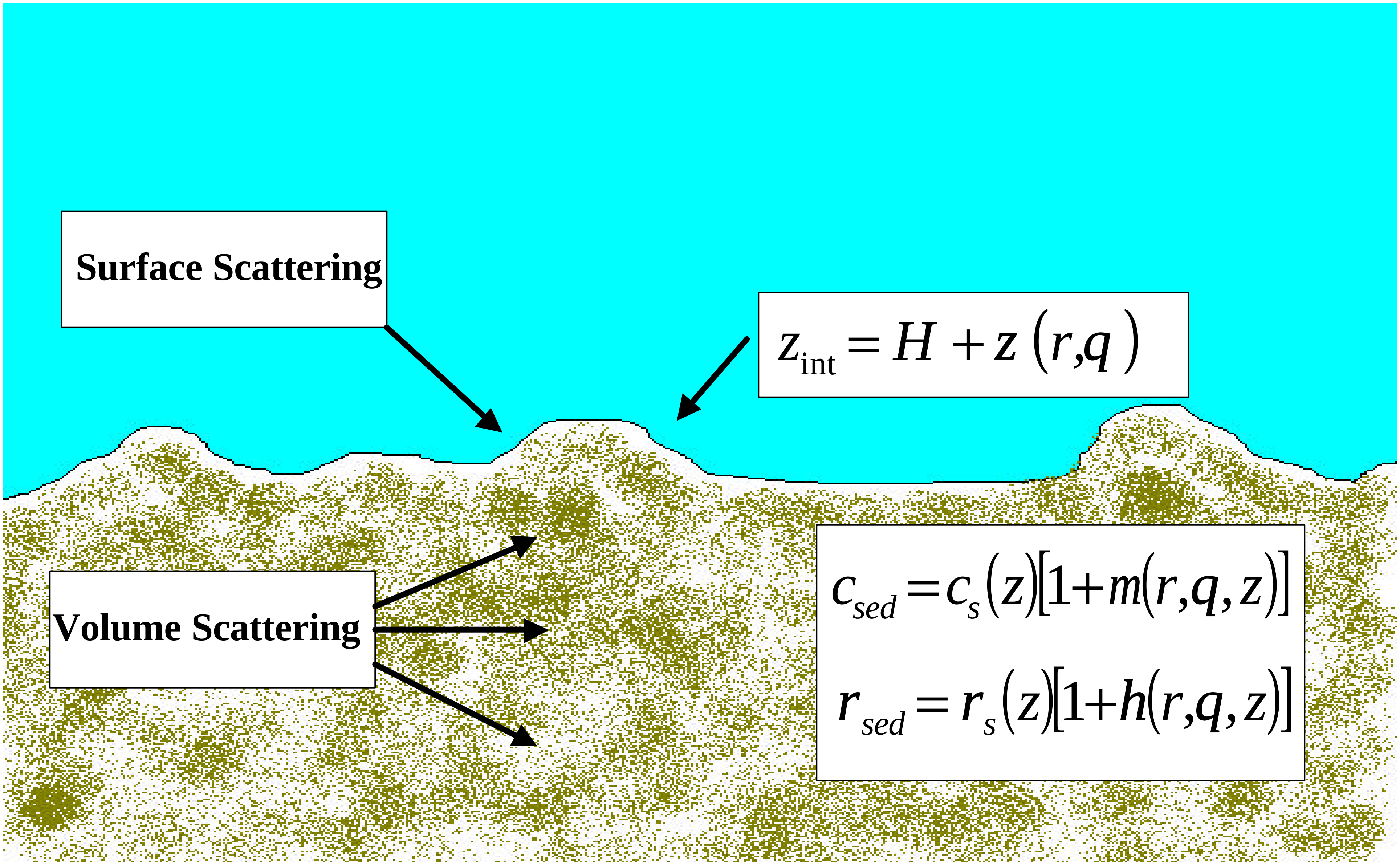
Sources of Reverberation



Model Assumptions

- Density fluctuations proportional to sound speed fluctuations: $h(\mathbf{r}) = 2gm(\mathbf{r})$
  - Sound speed fluctuations small: $|m(\mathbf{r})| << 1$
- Water sediment interface nearly flat, slightly rough: $|k_0 z(\mathbf{r})| << 1 \quad |\nabla_{\|} z(\mathbf{r})| << 1$
- Perturbation approximation: keep only first order terms in above small quantities

Equation for Scattered Field

$$
\mathrm{p}_{scat}(\mathbf{r}) = -\frac{1}{4p}\left\{
\begin{aligned}
&\int_{\mathrm{V}} (2g+2)\, m(\mathbf{r}')\, k_0^2(z')\left[\mathrm{G}_0(\mathbf{r};\mathbf{r}')\,\mathrm{G}(\mathbf{r}';\mathbf{r_0})\right] dV' \\
&-\int_{\mathrm{V}} (2g)\, m(\mathbf{r}')\left[\nabla'\mathrm{G}_0(\mathbf{r};\mathbf{r}')\cdot\nabla'\mathrm{G}(\mathbf{r}';\mathbf{r_0})\right] dV' \\
&+\int_{\mathrm{S}} (2g)\, m(\mathbf{r}'_-)\left[\mathrm{G}_0(\mathbf{r};\mathbf{r}'_+)\frac{\partial\,\mathrm{G}}{\partial z'}(\mathbf{r}'_+;\mathbf{r_0})\right] dA' \\
&+\int_{\mathrm{S}} z(\mathbf{r}')\left(1-\frac{r_w}{r_s}\right)\left[\nabla'_{\parallel}\mathrm{G}_0(\mathbf{r};\mathbf{r}'_+)\cdot\nabla'_{\parallel}\mathrm{G}(\mathbf{r}'_+;\mathbf{r_0})\right] dA' \\
&-\int_{\mathrm{S}} z(\mathbf{r}')\, w^2\left(\frac{1}{c_w^2}-\frac{r_w}{r_s c_s^2}\right)\left[\mathrm{G}_0(\mathbf{r};\mathbf{r}'_+)\,\mathrm{G}(\mathbf{r}'_+;\mathbf{r_0})\right] dA'
\end{aligned}
\right\}
$$

Fluctuation Fields

Described by radially isotropic, power-law, power spectra:

-Interface deviations:

$$W\left(k_r\right) = \frac{4pns^{2} l_r^{2}}{\left(1 + l_r^2 k_r^2\right)^{n+1}}$$

-Sound Speed Fluctuations:

$$W\left(k_r\right) = \frac{8p^{3/2} s^{2} l_r^2 l_z \Gamma\left(n + 3/2\right)}{\Gamma\left(n\right)\left(1 + l_r^2 k_r^2 + l_z^2 k_z^2\right)^{n+1}}$$

Simulation Details

- Single-scattering: Use Born Approximation (i.e. $G(\mathbf{r}_1;\mathbf{r}_2) = G_0(\mathbf{r}_1;\mathbf{r}_2)$)
- Monostatic scattering geometry
- Compute unperturbed Green’s function by normal mode decomposition
- Narrow (30 Hz) band processing
- Fit ensemble-averaged simulated time series to band-filtered time series via power spectrum parameters

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